PRODUCING EFFECTIVE INTERNET COURSES WITH inFUSION

Monson H. Hayes, Joel Jackson, and David Anderson

Abstract*— Since 1997, Georgia Tech has been delivering courses across the Atlantic to its sister campus in France using streaming media. Our experience has shown that, historically, there have been two significant obstacles that have been in the way of faculty and students being ready to embrace this technology, and accept this delivery mechanism for distance learning courses. First, in order for faculty to become involved in the development of "on-line" courses, the production process must be easy and convenient. Second, before either faculty or students are willing to go "on-line", both must be convinced that there are advantages to an Internet-based course over videotapes. In this paper we describe some of the work going on at Georgia Tech in the area of Internet distance learning, and describe a "turn-key" system that we have developed for producing streaming media lectures that make the production of online courses very easy. In addition, we describe what we see as the future of Internet-based distance learning.

***Index terms*—Distance learning, Internet education.**

I. INTRODUCTION

Georgia Tech is in a somewhat unique position of having a campus situated in the heart of Europe, in Metz, France, that offers Masters Degrees in Electrical and Computer Engineering and in Mechanical Engineering. This campus, known as Georgia Tech Lorraine (GTL), opened its doors to students in the Fall of 1991. Since the number of faculty at GTL has never been large enough to offer all of the courses necessary to support a complete Masters Degree program, a number of courses are delivered to GTL students through the Georgia Tech Center for Distance Learning. These courses, which are taught by Georgia Tech faculty to students in Atlanta, are videotaped, and the tapes are shipped, once a week, to GTL. However, for many reasons, offering courses by videotape is a problem. For example, associated with shipping tapes across the Atlantic is a relatively high cost in terms of time, labor, and shipping charges. In addition, there are unavoidable time delays, and these delays create problems for both students and faculty. A perhaps more serious problem, however, is the lack of interaction between faculty and student – the student is not able to stop the instructor to ask questions. Finally, it is generally acknowledged that videotaped lectures tend to be dull and uninteresting since typically all that is recorded is the instructor writing on a board or using overhead slides. Therefore, we believe that a much better learning environment would be one that allowed hypertext-based access to audio, video, and textual course information.

In the summer of 1997 we considered alternative methods of delivery, and in the Fall of 1997 began experimenting with Internet delivery of courses [1,2]. The initial course offerings only used PowerPoint slides that were synchronized to streaming audio of the lecture. In spite of its lack of richness, based on today's standards, due to the efficiency of this method, and the near instantaneous access students had to course materials, we embraced this technology and continued to evolve this approach. Today, we are streaming audio, video, text, and slides and, in some cases, chromakey video is used.[1]

Initially driven by a very real and pressing need to deliver courses in a timely and effective manner across the Atlantic, Internet course delivery is now finding its way into many different programs at Georgia Tech. For example, the School of Electrical and Computer Engineering (ECE) and the School of Mechanical Engineering (ME) are currently offering on-line Masters degree programs, and other schools within Georgia Tech are beginning the process of creating their own on –line degree programs. Another area in which Internet-based education is becoming important at Georgia Tech is in corporate training and continuing education. Traditional University involvement in continuing education has been through short courses or video courses. Short courses are usually offered over a period of several days at the University campus. They can be effective, but may disrupt an employee's work schedule and, since the course is often offered at a remote location, there may be the added inconvenience and increased cost of travel. Video courses, unless delivered real-time over dedicated satellite or network connections, provide very little interactivity. Internet-based education shows promise in many respects, including:

1. Materials may be delivered either synchronously or asynchronously;
2. Multiple modes of presentation are available;
3. Many types of interactivity are possible, including on-line evaluation and assessment;
4. World-wide delivery is possible;
5. Delivery costs may be reduced.

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[1] This is the technique that is often used in weather forecasts on television.

In spite of Georgia Tech's expanding use of the Internet for on-line education and training, and even with the advantages that the Internet offers over videotaped course delivery, there are still some problems with Internet-based delivery. Some of these problems will be discussed in this paper as we describe our most recent experiment with Internet-based education – an extremely successful on-line course entitled *DSP for Practicing Engineers* that involves multiple instructors, a laboratory, and a low bandwidth requirement. This course, now in the third offering this year, has had enrollments of nearly 50 students from throughout the world, and it is the product of a joint cooperation between Georgia Tech and Texas Instruments [3].

II. On-Line Course Delivery Options

There are many options available for Internet delivery of educational material. Some possibilities include:

1. HTML only,
2. HTML synchronized with audio,
3. HTML with synchronized audio and Flash animation,
4. Streaming video only,
5. Streaming video synchronized with an HTML presentation, and
6. Streaming video, Flash animation, HTML slides, Java-enhanced pages, etc.

For bandwidth-constrained environments, e.g. 56 Kbps or less, the first three methods are preferred. The first, HTML-based presentations can be effective, but it is challenging to design pages that convey enough information in an engaging manner. Also, it is unlikely that such a course would meet the demands of students wanting to take a University course. The second option, HTML that is synchronized with audio, is used by a number of on-line training organizations, such as TechOn-Line, www.techonline.com, which uses professional speakers to record scripts that are prepared by the instructor. We believe that this mode of delivery is not a very effective training format. Adding Flash animation to a synchronized streaming audio presentation as in the third option will lead to more engaging course materials, but the primary difficulty with this approach is the large amount of production time that is necessary to prepare quality presentations.

For higher bandwidth connections, e.g. greater than 56 Kbps, the delivery of streaming video becomes possible. However, for high-quality video, even LAN connections can have problems when competing network traffic causes intermittent congestion. Since the fourth option entails sending the video of the lecture over the network, because of the high resolution (and hence, high bandwidth) that is necessary to convey written information, this method is currently impractical for general Internet delivery. Option 5, which consists of streaming video that is synchronized with an HTML presentation, makes it possible to use smaller, lower-bandwidth video to show the presenter or supplemental information while using the HTML presentation to convey all written information, i.e., text and graphics. The sixth option, which includes all aspects of the first five options, has the possibility for providing the richest learning environment along with the most amount of interactivity. However, to produce an effective presentation, this option is extremely time-intensive.

It should be pointed out that with any of the options mentioned above, the structure and format of an Internet-based course is limited only by the imagination and creativity of the course designer. And we believe that it will be the innovation of the educator that will be the driving force in how Internet course delivery will evolve over the next few years.

III. Internet Course Production

As noted in the Introduction, there are many advantages to offering courses over the Internet as opposed to more traditional methods, such as videotapes, and it is clear that Internet distance learning will become widespread in the future. In fact, today we are currently witnessing an explosion in the delivery of on-line courses [5], and some Universities are putting complete degree programs on the Web. What the Internet offers is the ability to deliver courses throughout the world, anytime and anyplace. Internet-based courses also offer the student fast and efficient navigation through a lecture, fast retrieval of multimedia content, along with course and lecture indexing. Internet courses may also offer keyword searches through multimedia content, self-assessment tools, interactive content, and hyperlinks to related course material.

Presently, there are some difficulties associated with the offering of courses over the Internet. Some of these will go away in the future, while others will not. Up until the end of last year, what we observed at Georgia Tech was that, in spite of seminars that were given to faculty to encourage them to get involved with Internet distance learning, faculty participation was spotty, at best, although faculty curiosity and interest was high. Other studies have indicated that faculty at Georgia Tech was not alone regarding their reluctance to participate in distance education [6]. There are a variety of reasons for this. For example, to develop a course for Internet delivery, it is necessary for faculty to commit a significant amount of time creating the course content. There may never be a way to ameliorate this, short of hiring a staff of content design experts. Another issue involves the constraints that must be placed on teaching methodologies that faculty use in delivering courses over the Internet. Since some teaching styles do not lend themselves to Internet delivery, faculty must be willing to adapt the way that they teach. Another aspect of distance learning some instructors find discouraging is the lack of contact that they have with the students, and the enlarged role that they must assume in encouraging and facilitating classroom participation. Finally, there is a significant investment in start-up time that is required to design a course and bring it on-line. This is due the absence of powerful and effective tools that enable the instructor to quickly and efficiently design an audio- and video-enhanced course and bring it on-line. To makes things

worse, faculty investing the time and effort to produce Internet-based courses typically do not receive any extra compensation or release time and, in some cases, there is no recognition for their efforts.

A. DSP For Practicing Engineers

In the spring of 1999, the Center for Signal and Image Processing (CSIP) within the School of ECE at Georgia Tech began the design of an Internet-based course entitled *DSP For Practicing* Engineers. This course, twelve weeks in duration, was to involve six faculty, include audio and video clips, HTML pages with text and graphics, Matlab exercises, and a hardware laboratory using Texas Instruments DSP chips. This course was to be delivered, asynchronously, to an audience that spanned the globe. Given the size and scope of the project, a considerable amount of thought was given to how it should be designed, produced, and delivered. Unlike many other on-line courses, we chose to structure the course using lecture "modules" that are anywhere from five to fifteen minutes in duration. There are several reasons for using short lecture modules. The first is that short modules are better suited to the effective attention span of the student. The second reason is that it is much easier for an instructor to prepare, produce, edit, and modify short lecture modules compared to a full hour lecture. The third is that is that it is much easier for modules to be "repackaged" into short courses, or shared with other Internet-based courses.

B. The Bandwidth Hurdle

Even with small, compressed video (150x100 pixels) at ten frames per second, the bandwidth that is required is too large for slow Internet connections that are subject to traffic congestion. To address this problem, we have been using a hybrid delivery method that involves sending students a CD-ROM that contains the lecture material (audio, video, HTML, and graphics). The course organization (discussion groups, assignments, class announcements, etc.) is delivered through WebCT (www.webct.com), a web course tool that permits each student to login and keeps track of individual information, accesses, and statistics. WebCT also provides a tool to control access to the student's CD-ROM drives. This arrangement permits the viewing of high-bandwidth, high-quality presentations in a web browser while keeping control of the course from a central location using a low-bandwidth connection.

C. InFUSION – A Set of Course Production Tools

As previously mentioned, a tremendous investment in start time is required to design and develop a course for Internet delivery. By far the most significant investment in time is in content preparation. However, once the course content has been created, to produce a streaming media course, a large amount of tedious work is required. This work includes the extraction of timing information for slide synchronization, the writing of SMIL files that orchestrate the streaming media production, and the design of the HTML pages and links. Therefore, we decided to write a scripting program that would automate the recording of timing information, and generate all of the necessary streaming media files. The result was a set of simple tools, written in Perl that reduced the production time from a couple of hours to a few minutes. The next step was to develop a user-friendly front-end that would allow an instructor to publish his or her content for Internet delivery without having to use command line instructions. At the same time, some useful generalizations and extensions to the original program were added, including

1. Support for multiple types of video cameras,
2. A variety of "skins" for the course pages,
3. A live-action video window for monitoring the video capture, and
4. Slideshow viewing and editing capabilities.

The end result was a program inFusion that consists of a set of tools for producing lecture modules. This program is powerful, yet easy to use, and has a user interface that is illustrated in Figure 1. All that the instructor needs to provide as input to the program are postscript files containing the slides, or individual images of the slides in GIF, JPEG or PNG format. Then, with a video camera focused on the instructor, a lecture module is captured to disk while progressing through the slideshow. Once the video has been encoded, the tool is then ready to automatically generate all of the necessary streaming media files. An example illustrating one of the presentation formats that this program generates is shown in Figure 2. The presentation format is flexible, allowing the user to change backgrounds, the elements included, and the layout. This allows the creation of lectures including only audio, or with additional information in the windows around the slide, thus allowing the instructor to tailor the presentation to his teaching style or the learning style of his students. Any of the media windows can be made *hot* with links to supplementary material that change as the presentation progresses. This allows a single window to be used as a "Supplementary Information" window, with extra readings or links that correspond to the portion of the lecture currently being viewed. The primary advantages of these tools are simplicity and portability. Although many of our Internet courses are filmed in a small studio, instructors can capture lectures in their own office, at home, or in the classroom. This set of tools is currently available, free of charge, from the website www.ece.gatech.edu/streaming.

In discussing on-line courses, there are two approaches that one may consider. The first is to "capture" the classroom during a live lecture, and place it on the Internet for distance learning students. The second is to produce lectures or lecture modules outside of class in a studio or office, and produce an Internet version of a course. In the second case, the *in*Fusion tools allow for both the capture and the placement of the audio, video, and HTML pages on the Internet. In the first case, *in*Fusion could be used to capture all of the timing information for synchronization, and the production of the necessary multimedia files could be done outside of class at a later time.

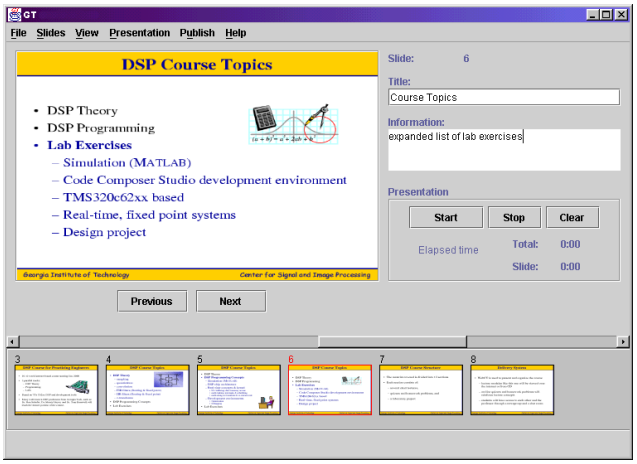

FIGURE 1: The user interface.

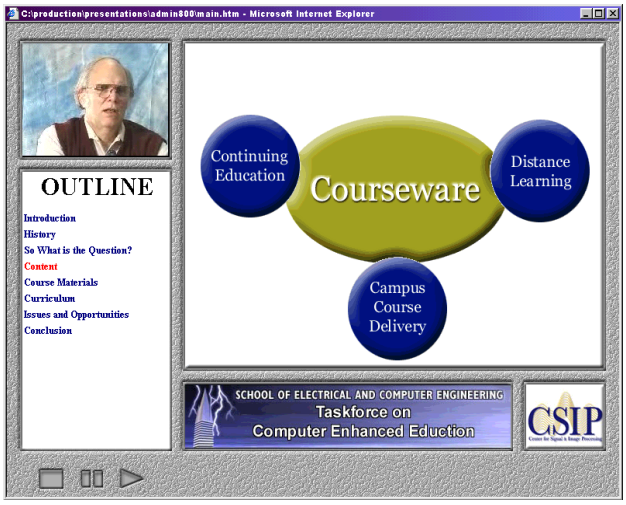

FIGURE 2: A screen shot of a streaming media course produced using our development tools.

Having created a simple set of tools to bring synchronized and indexed audio and video easily onto the Internet, the next set of issues that should be addressed center around how to make effective course content that will enhance the learning environment for the student. Another issue is how to create a set of tools for designing courses that will allow for indexing and searching without and across courses, assessment, evaluation, and course flow that is dependent upon the student's learning style.

IV. The Future

Developing distance-learning environments offers the opportunity to redefine the classroom concept, and to expand the repertoire of tools available to the instructor. These tools can be grouped into two categories: lecture delivery and enhanced materials. The first provides the applications necessary to produce and deliver the fundamental lecture from the primary site. The latter category deals with those materials that enhance the learning environment and expand the resources available to the student. Over the last few years, we have given a lot of thought on how to enhance the learning environment, and we are now beginning to implement some of these enhancements.

The first enhancement that we are in the process of developing involves the development of effective ways that will allow the student to efficiently search for information within the course materials [8]. For example, we believe that the student should be able to enter keywords into a computer, either by typing them using the keyboard or by speaking into a microphone, to find some desired information or content. More generally, the student may wish to search for information about a topic over an entire library of courses. Although eventually the student should be able to search over all types of media, i.e., text, graphics, audio, and video, up to this point in time we have only focused on searching over textual information, such as slides. Clearly, the generation of the index that is to be used for content searching should be automated so that keywords do not need to be entered manually into a database, or manually linked to audio and video content. Therefore, what we are developing is a program for automatically generating a key-word index from postscript slides, and linking these words back to the multimedia course content.

Another enhancement that we believe will be important in the future is to allow the student to be able to interact with his/her learning environment. This will involve a number of different aspects. First, the student should be provided with an effective note-taking environment. This would include allowing the student to be able to capture text and graphics information for annotation. In addition, the student may wish to capture short audio or video clips for future listening or viewing. The student should also be given the tools that would enable him/her to apply electronic post-it notes to tag information that is important or confusing. For information that is confusing, the student should be able to send the content along with the post-it note to the instructor for clarification.

Assessment of student learning is, without a doubt, something that will be important in any electronic course. For example, it will be important for the student to be able to assess his or her understanding of a course module before proceeding onto the next. There are several ways that this assessment could be performed, and which one is best is a subject for debate. One approach would be to have a set of questions, some percentage of which must be answered correctly, before he/she is allowed to proceed onto the next module. Alternatively, the student could be directed to some other course material or problems to work if some deficiency in understanding is detected.

Finally, as course development tools and software become more sophisticated and readily available, we may find the student being able to proceed through the course using a path that depends on his/her learning styles. We expect, for example, learning theory to become increasingly important in developing Internet-based courses in the future.

Over the next few years, we can expect to see new technologies being used in courses that are delivered over

the Internet. These new technologies will undoubtedly include the following:

1. Tools that will automatically search and index audio using voice recognition technologies,
2. The incorporation of natural language interfaces for information searching and retrieval,
3. Synthesis of speech from text to facilitate learning for the visually impaired, and automatic captioning for the hearing impaired.

It is clear that Internet-based education and training is gaining momentum. Although we do not expect the Internet to replace the classroom, we do believe that it will become an increasingly important vehicle for delivering educational materials to those that do not have access to a university and to those that do not have a schedule that permits their attending class during normal hours. We also believe that Internet will be used increasingly in the future as a tool that is able to extend the walls of the classroom, and provide a richer and more diverse learning environment for the student.

V. SUMMARY

In this paper, we have described some of the initiatives at Georgia Tech in the area of Internet-based education, and we have discussed some of the problems, as we see them, in using the Internet for distance learning. We have also described a set of tools that we have developed for automating the process of creating streaming media modules for Internet-based courses. Since a complete course consists of a number of interconnected lecture modules, some of our current efforts are focused on the task of developing the tools necessary to bundle these modules together to produce a "course". Such "*Course Authoring Software"* should automate the process of generating indexes, incorporate tools for the assessment of student learning, provide some way for the student to ask questions, etc. Finally, we have given some of our thoughts on what we might expect to find in the future in the area of Internet distance learning.

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